TERRESTRIAL AND ATMOSPHERIC DEPOSITION STUDIES IN THE VICINITY OF THE ONTARIO HYDRO THERMAL GENERATING STATION, ATIKOKAN, 1986

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ATIKOKAN, 1986

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RÉSUMÉ

En 1986, première année d'exploitation de la centrale d'Atikokan d'Ontario Hydro, le Ministère a effectué une analyse du milieu terrestre des environs.

On a relevé, près de la centrale, des concentrations élevées d'asenic et de fer et des concentrations assez élevées de chrome, de manganèse, de nickel, de sélénium et de zinc. Cette contamination du milieu terrestre provenait des émissions rejetées antérieurement par les mines de fer et les usines de frittage de boulettes qui étaient en activité pendant une quinzaine d'années près de l'emplacement actuel de la centrale.

Les résultats des analyses chimiques du feuillage, de la mousse, des précipitations et de la neige ont révélé que les concentrations actuelles dans l'air de tous les polluants mesurés en 1986 sont peu élevées et bien en-deçà des concentrations de fond normales.

D'après les analyses décrites dans le présent rapport, rien ne prouve que les activités de la centrale d'Atikokan en 1986 aient eu des répercussions sur le milieu terrestre. Toutefois, le programme de surveillance se poursuivra au moins jusqu'à la fin de 1988.

INTRODUCTION

In 1981, the Ontario Ministry of the Environment began terrestrial and atmospheric deposition monitoring around a thermal generating station under construction near the Town of Atikokan in northwestern Ontario. The power plant, owned by Ontario Hydro, comprises a single 200 megawatt unit fueled with low-sulphur lignite from western Canada. The station was commissioned in late 1985.

Results[1,2,3,4] of the pre-operational monitoring period revealed elevated levels of iron and arsenic in soil and in some types of vegetation at sampling sites near the power plant. Air emissions from two former iron ore pelletizing plants nearby were responsible for this contamination.

This report summarizes terrestrial and deposition data obtained during the first year of plant operation in 1986. In 1986, the generating station was on a basic operating schedule of 16 hours per day, 5 days a week. There were brief outages during the first months of the year and a maintenance shutdown from mid-June to mid-August.

METHODS

TERRESTRIAL STUDIES

Samples from 15 locations (figure 1) were collected for chemical analysis. From each site, where present, foliage samples were collected from white birch, current and one-year old white pine, beaked hazel, mountain maple and willow. Feather moss (*Pleurozium schreberi*), a foliose lichen (*Umbilicaria muhlenbergii*), and a fruticose lichen (*Cladina rangiferina*) were also sampled.

Bark samples were obtained at a height of 1 to $1\frac{1}{2}$m (metres) above ground from stems of white pine trees sampled for foliage. Dried Sphagnum moss in open mesh polypropylene bags was exposed at all sampling sites for about a 60-day period during June and July. Standard Ministry procedures[5] were used to collect samples and expose moss bags.

All vegetation and bark samples were analyzed for aluminum, arsenic, cadmium, chloride, chromium, copper, fluoride, iron, lead, mercury, manganese, nickel, selenium, sodium, sulphur and zinc at the Ministry's laboratories in Toronto and Thunder Bay. In addition to the foregoing analyses, soil was analyzed for calcium, organic matter, magnesium, phosphorous and potassium. Soil and bark pH were also determined.

Vegetation in the vicinity of sampling sites was examined for visible evidence of stress caused by disease, insects, contaminants and physiological factors.

Contaminant guidelines developed by the Ministry for vegetation and moss are used in this report. Their exceedence would suggest that contamination may be present but would not necessarily imply adverse effects.

ATMOSPHERIC DEPOSITION STUDIES

As part of the Acidic Precipitation in Ontario Study (APIOS), the Ontario Ministry of the Environment operates deposition monitoring equipment at Quetico Centre (30 km east-southeast of the generating station), at Lac La Croix (70 km southwest), at Fernberg Road in northern Minnesota (95 km south), and at Dawson Township (135 km east) (see Figure 2). Dawson Township serves as a control site for comparison with data from the other three sites. Cumulative (28-day) precipitation and daily precipitation began at some of these sites in late 1980. Specific network descriptions and monitoring methods used are published elsewhere.[6,7]

The snow profile was sampled in February, 1986 at 11 of the sites shown in Figure 1. Snow from sites 4, 9, 11 and 15 was not sampled due to access problems. Standard Ministry collection and processing procedures were followed.[5] Samples were analyzed for the same parameters as vegetation, plus calcium, carbon, conductivity, magnesium, phosphorus, potassium, residues and pH. Parameter levels were compared with contaminant guidelines used by the Ministry.

RESULTS

VEGETATION AND SOIL

Tree and Shrub Foliage

Insect damage to vegetation in the study area was light. Minor insect injury was caused by white birch leaf miner, by trembling aspen and balsam poplar leaf-blotch miner, by saw-fly on mountain ash, and by grey willow leaf beetle on willow. Light damage was also caused by mites on mountain maple and on red maple foliage. There were no visible symptoms of air pollution injury to vegetation.

Chemical analysis results are presented in Table 1. Occasionally, contaminant guidelines were exceeded for aluminum, nickel, selenium and iron. However, 99% of the results for measured contaminants were within normal background concentration ranges. Guideline exceedences had no apparent relationship with emissions from the generating station.

White Pine Bark, Moss and Lichens

Chemical analysis summaries are presented in Table 1. Arsenic and iron occurred at elevated levels in feather moss, lichens and white pine bark collected from some sites. These elevated

concentrations result from air emissions from two former iron ore mines which operated in the area from the mid 1960's to about 1980. Arsenic and iron concentrations in white pine bark and feather moss are compared in Table 2 for 1981-83 (pre-operational period) and 1986 (first year of service). This comparison shows that concentrations of arsenic have decreased; iron did not show an overall trend.

Table 3 presents a correlation matrix between pairs of elements in feather moss, and between element levels and sampling distance from the power plant. There were significant positive correlations between several element pairs, most of which reflect contamination from the former iron mine operations. The negative correlation between arsenic levels and distance from the power plant indicates that arsenic enrichment in feather moss was caused by emissions from the former iron mines.

Table 4 summarizes analytical results from the moss exposure experiment. Levels of all chemical elements were low and well within the range expected in areas remote from pollution sources. Ministry guidelines were not exceeded. The relationship between selected element concentrations in moss and distance from the generating station was evaluated. There were no significant correlations either for the 1981-83 pre-operational period or for 1986.

Soil

Chemical analysis results are presented in Table 5. Levels of iron and arsenic were elevated in soils. Highest levels of these two elements were found in surface soils and levels usually decreased with increasing soil depth (Table 6). Although sampling depths in this study differ from the standard depth (0-5 cm) for contaminant guidelines, the data indicate that the arsenic guideline

would have been exceeded at sites 1, 2, 3, 4, 8, 9, and 11. Similarly, the iron guideline would have been exceeded at site 4. Arsenic and iron have not changed significantly from levels recorded during pre-operational surveys.

As reported in previous surveys, levels of mercury in surface soils were higher than expected. The cause of the elevated mercury remains unknown but is ascribed to natural causes.

ATMOSPHERIC DEPOSITION STUDIES

Precipitation

Table 7 compares the 1982-84 pre-operational precipitation chemistry data with results for 1986. Precipitation chemistry and wet deposition rates were similar at the four sites in 1986 and were essentially unchanged from pre-operational levels. Wet sulphate deposition was low and within a range considered normal for the area. Deposition rates less than 20 kilograms per hectare per year are unlikely to damage sensitive aquatic systems.

Snowpack

Chemical analysis results are summarized in Table 8. Levels of all parameters in the snowpack were well below established Ministry guidelines and were typical of background ranges expected in snow in areas remote from pollution sources.

SUMMARY AND DISCUSSION

A survey of the terrestrial environment was conducted around Ontario Hydro's Atikokan generating station in 1986, the first year of the power plant's operation.

There was significant terrestrial contamination by arsenic and iron and slightly elevated concentrations of chromium, manganese, nickel, selenium and zinc near the power plant. This situation was caused by historical emissions from two former iron ore mines and pelletizing plants which operated for about 15 years near the present location of the power plant.

Chemical analysis of tree foliage, exposed moss, precipitation and snow demonstrated that current atmospheric concentrations of all measured parameters in 1986 were low and well within normal background ranges.

The studies described in this report provided no evidence of measurable impact on the terrestrial environment resulting from operation of the Atikokan power plant in 1986. Assessment surveys will continue at Atikokan at least until the end of 1988.

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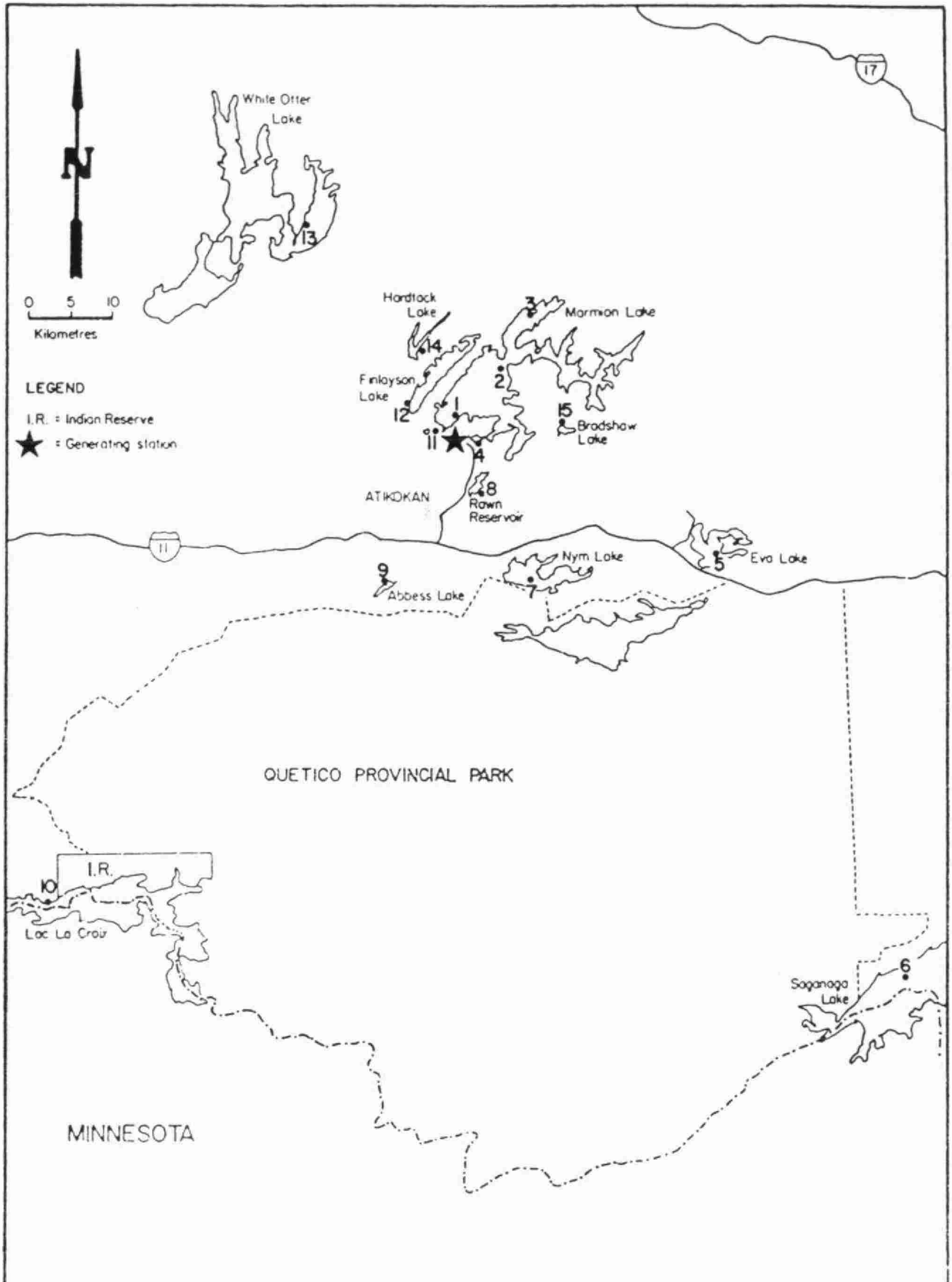

Figure I. Vegetation, soil and snow sampling sites, Atikokan, 1986.

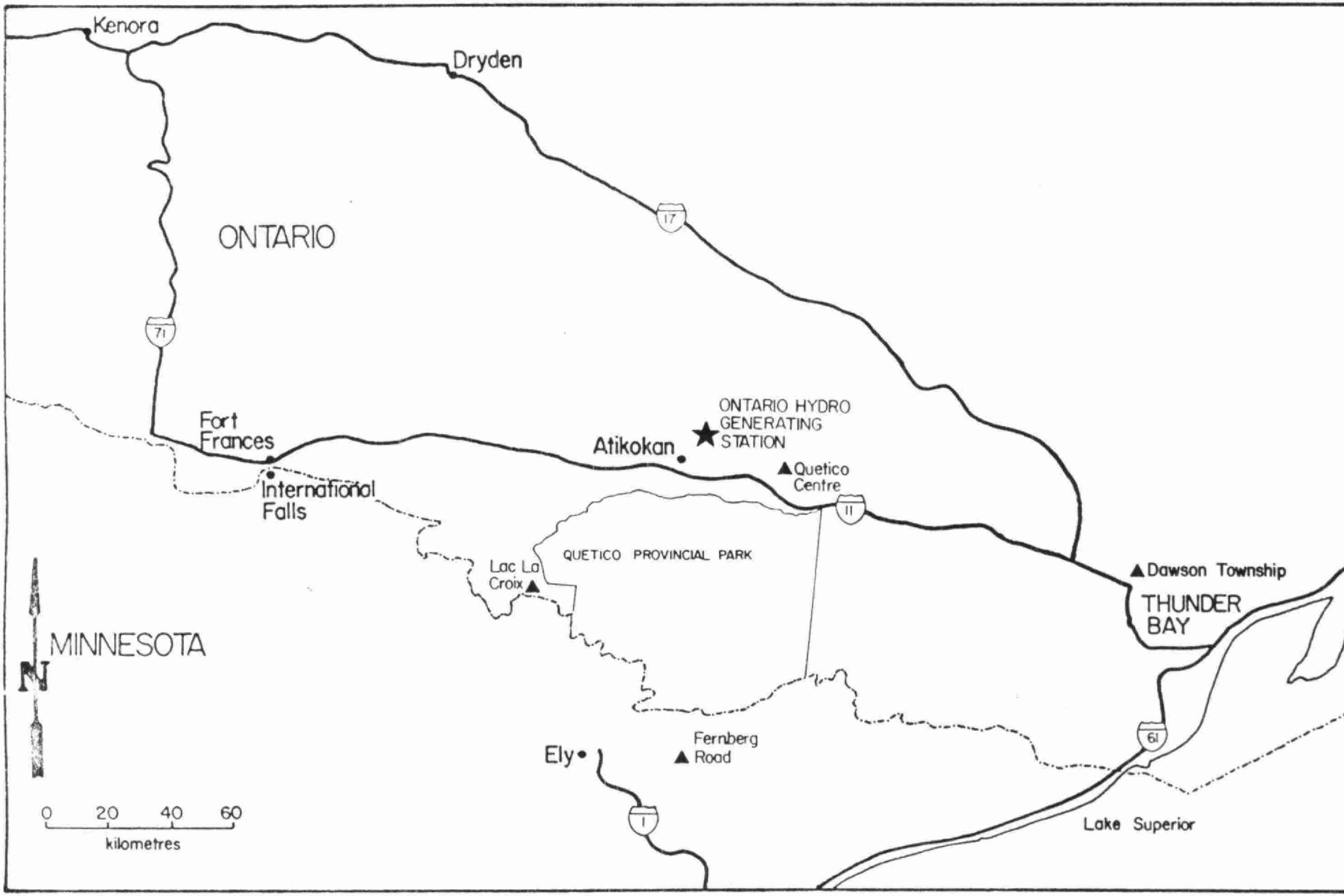

Figure 2. Precipitation sampling sites (▲), Atikokan.

TABLE 1. Levels of selected elements and pH in vegetation, Atikokan, 1986. All elemental values are in μg/g, dry weight, except chloride and sulphur, which are in percent, dry weight.

Plant species	Mean and range	Element																
		Al	As	Cd	Cl	Cr	Cu	F	Fe	Pb	Mn	Hg	Ni	Se	Na	S	Ti	Zn
White pine[a] (current)	Maximum	230	<0.1	0.2	0.02	2	6	<1	50	<1	360	<0.03	7	0.2	34	0.11	<2	44
	Mean	160	<0.1	<0.1	0.01	<1	4	<1	35	<1	169	<0.03	3	<0.1	<20	0.09	<2	34
	Minimum	110	<0.1	<0.1	<0.01	<1	3	<1	26	<1	72	<0.03	1	<0.1	<20	0.07	<2	24
	Std. dev[b]	35	0	0	0.01	0.5	0.9	0	6	0	87	0	2	0.04	9	0.01	0	6
White pine[a] (1-yr-old)	Maximum	470	0.2	0.3	0.02	5	3	<1	120	1	1300	0.03	6	0.4	28	0.10	5	94
	Mean	350	<0.1	0.1	0.01	2	3	<1	90	<1	400	<0.03	2	0.2	<20	0.08	4	44
	Minimum	290	<0.1	<0.1	<0.01	<1	2	<1	65	<1	110	<0.03	<1	<0.1	<20	0.06	2	19
	Std. dev	54	0.04	0.1	0.01	1	0.4	0	17	0	310	0.00	2	0.1	6	0.01	1	22
White birch	Maximum	55	0.1	0.9	0.05	8	7	1	83	3	1800	<0.03	7	0.8	<20	0.14	3	180
	Mean	37	<0.1	0.4	<0.01	4	5	<1	66	<1	740	<0.03	3	0.2	<20	0.11	<2	100
	Minimum	21	<0.1	0.2	<0.01	2	4	<1	43	<1	100	<0.03	1	<0.1	<20	0.09	<2	10
	Std. dev	10	0.01	0.2	0.01	1.7	1	0.3	12	1	430	0	1	0.2	0	0.02	1	57
Beaked hazel	Maximum	220	<0.1	0.6	0.07	7	8	1	160	1	1400	<0.03	3	0.2	20	0.15	13	130
	Mean	100	<0.1	0.1	0.04	5	5	<1	94	<1	1000	<0.03	2	0.1	<20	0.11	5	31
	Minimum	32	<0.1	<0.1	<0.01	4	4	<1	57	<1	780	<0.03	2	0.1	<20	0.08	<2	11
	Std. dev	63	0	0.2	0.02	1	1	0.2	35	0	190	0	0	0.04	4	0.02	4	44
Mountain maple	Maximum	90	0.4	0.7	0.13	5	8	1	150	1	1000	<0.03	2	0.1	31	0.14	6	53
	Mean	60	0.1	0.3	0.09	3	6	<1	95	<1	540	<0.03	1	<0.1	<20	0.13	3	33
	Minimum	34	<0.1	0.1	0.06	<1	5	<1	65	<1	91	<0.03	<1	<0.1	<20	0.11	<2	22
	Std. dev	18	0.1	0.2	0.02	2	1	0.2	29	0	310	0	1	0.03	9	0.01	2	11

TABLE 1 (continued) Levels of selected elements and pH in vegetation, Atikokan, 1986. All elemental values are in $\mu g/g$, dry weight, except chloride and sulphur, which are in percent, dry weight.

Plant species	Mean and range	Element																	
		Al	As	Cd	Cl	Cr	Cu	F	Fe	Pb	Mn	Hg	Ni	Se	Na	S	Ti	Zn	pH
Willow	Maximum	630	<0.1	1.7	0.05	3	9	<1	670	9	450	<0.03	12	1.1	35	0.34	4	190	
	Mean	93	<0.1	0.8	0.03	1	6	<1	130	2	190	<0.03	4	0.2	<20	0.19	<2	77	
	Minimum	22	<0.1	0.2	0.01	<1	2	<1	56	<1	28	<0.03	<1	<0.1	<20	0.09	<2	19	
	Std. dev	170	0	0.5	0.01	1	2	0	170	2	125	0	3	0.3	7	0.06	1	52	
Pleurozium[a] schreberi	Maximum	2700	5.9	0.6	<0.01	24	10	<1	8400	16	790	0.15	10	1.5	66	0.10	160	66	
	Mean	1200	2.2	0.3	<0.01	5	4	<1	2700	10	300	0.10	3	0.5	36	0.07	78	35	
	Minimum	590	0.3	0.1	<0.01	1	3	<1	770	6	100	0.06	1	0.1	<20	0.04	44	22	
	Std. dev	530	2.0	0.1	0	6	2	0	2500	3	180	0.03	2	0.3	16	0.02	31	12	
Cladina[a] rangiferina (lichen)	Maximum	670	3.3	0.3	<0.01	2	3	<1	2500	6	85	0.08	2	0.6	56	0.05	60	21	
	Mean	550	0.9	0.2	<0.01	<1	2	<1	1000	4	50	0.05	<1	0.2	22	0.03	41	16	
	Minimum	410	0.1	0.1	<0.01	<1	1	<1	480	3	24	<0.03	<1	<0.1	<20	0.02	19	12	
	Std. dev	80	0.8	0.1	0	0.4	4	0	550	1	21	0.02	1	0.2	14	0.01	12	2	
Umbilicaria[a] muhlenbergii	Maximum	1700	11.0	0.4	0.01	7	11	<1	7900	29	69	0.16	5	3.9	68	0.15	98	53	
	Mean	1100	3.6	0.1	<0.01	4	4	<1	2800	19	34	0.12	3	1.4	43	0.11	60	33	
	Minimum	570	0.8	<0.1	<0.01	2	3	<1	1000	9	19	0.09	1	0.2	<20	0.08	2	25	
	Std. dev	290	3.0	0.1	0	1	2	0	1900	6	15	0.02	1	1.1	19	0.02	34	7	
White pine bark[a]	Maximum	1100	5.4	0.4	<0.01	6	7	<1	4600	15	110	0.13	3	0.8	21	0.04	44	110	4.0
	Mean	550	1.4	0.2	<0.01	2	3	<1	1100	5	54	0.08	1	0.3	<20	0.02	18	35	3.6
	Minimum	280	0.2	<0.1	<0.01	<1	2	<1	250	2	18	0.05	<1	0.1	<20	<0.01	6	21	3.1
	Std. dev	200	1.7	0.1	0	2	1	0	1200	4	28	0.03	1	0.2	3	0.01	0	22	0.2
Contaminant[c] guidelines		500	2.0	1.0[d]	0.15	8	20	15	500	30	3000	0.10	5	0.5	50	0.40		250[d]	

[a] Contaminant guidelines do not apply.
[b] Standard deviation of the mean.
[c] Applies to deciduous trees and shrub foliage only.
[d] Does not apply to accumulator species (willow and birch)

TABLE 2. Average levels of arsenic and iron ($\mu g/g$, dry weight) in white pine bark and feather moss (*Pleurozium schreberi*), Atikokan, 1981-83 and 1986.

	White pine bark				Feather moss			
	Arsenic		Iron		Arsenic		Iron	
Site	1981-83[a]	1986	1981-83[a]	1986	1981-83[a]	1986	1981-83[a]	1986
1	11.9	5.4	3500	3400	7.4	2.6	5500	8100
2	4.5	2.6	2200	1500	3.1	1.8	1900	1600
3	1.5	1.0	790	1100	3.6	1.1	2000	1200
4	5.6	5.0	2700	4600	10.9	5.9	6300	4700
5	0.5	0.3	430	430	1.3	0.5	1200	940
6	0.3	0.2	360	250	0.4	0.3	610	830
7	0.8	0.4	360	490	2.2	1.0	1900	2400
8	8.1	1.7	3400	1300	5.9	5.2	3300	3200
9	0.6	0.3	350	480	1.4	0.9	1400	1600
10	0.5	0.2	510	440	0.5	0.3	1400	1300
11	2.9	1.0	610	720	9.9	5.2	5500	3400
12	5.7	1.6	2500	1300	4.9	5.0	3800	8400
13	0.5	0.4	330	350	1.0	0.7	1000	1200
14	1.3	0.5	400	360	1.4	1.1	1100	1500
15[b]	1.2	0.8	520	480	2.4	1.4	2500	770
Mean	3.2	1.4	1300	1100	3.9	2.2	2700	2700

[a] Average of three years of sampling.
[b] Sampling began in 1983.

TABLE 3. Correlation matrix of selected elements[a] in feather moss (Pleurozium schreberi), Atikokan, 1986.

	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Na	S	Zn
As	0.51*													
Cd	0.14	0.33												
Cr	0.95*	0.61*	0.29											
Cu	0.88*	0.46	0.37	0.90*										
Fe	0.94*	0.66*	0.22	0.93*	0.81*									
Pb	0.81*	0.47	0.19	0.81*	0.65*	0.81*								
Mn	0.79*	0.27	0.19	0.80*	0.83*	0.70*	0.62							
Hg	-0.53*	-0.31	-0.40	-0.60*	-0.41	-0.54*	-0.54*	-0.36						
Ni	0.94*	0.50*	0.31	0.97*	0.94	0.86*	0.76*	0.84*	-0.55					
Se	-0.01	0.52*	-0.25	-0.04	-0.23	0.13	-0.02	-0.20	-0.13	-0.15				
Na	0.07	0.20	0.52	0.08	0.04	0.04	0.07	-0.03	-0.33	0.02	-0.09			
S	-0.05	-0.01	0.10	-0.16	0.08	-0.01	-0.22	-0.04	0.31	-0.09	0.25	-0.27		
Zn	0.38	0.42	0.75*	0.40	0.53*	0.50*	0.25	0.29	-0.24	0.41	0.08	0.44	0.47	
Distance[b]	-0.36	-0.61*	-0.32	-0.42	-0.34	-0.48	-0.27	-0.42	0.14	-0.33	-0.36	0.07	-0.21	-0.31

[a] Cl and F are excluded because concentrations were uniform and near detection limit.
*Denotes a significant Pearson correlation for pairs of elements at P <0.05.
[b] Distance from generating station.

TABLE 5. Levels of selected elements and pH in three depths of soil, Atikokan, 1986. All elemental values are in μg/g, dry weight, except aluminum, calcium, iron, magnesium, potassium and sulphur, which are in percent, dry weight.

	Al	As	Cd	Ca	Cl[b]	Cr	Cu	F	Fe	Pb	Mg	Mn	Hg	Ni	P	K	Se	Na	S	Ti	Zn	pH
Soil(0-1 cm)																						
Maximum	1.2	160	1.0	1.7	83	89	290	100	9.9	73	.96	1900	0.4	38	1.5	.12	2.6	300	0.16	3600	230	6.6
Mean	0.5	36	0.6	0.8	47	29	56	12	2.5	52	.19	540	0.2	16	0.9	.08	0.9	105	0.11	2100	70	4.7
Minimum	0.2	1.2	<0.2	0.3	8	7	17	3.0	0.4	15	.07	90	<0.03	5	0.6	.05	<0.1	37	0.04	1000	26	3.8
Std. dev.	0.2	47	0.2	0.4	20	28	67	24	2.7	15	.22	520	0.09	11	0.3	.02	0.9	65	0.03	810	52	0.8
Soil(1-2 cm)																						
Maximum	1.4	110	0.9	1.4	85	100	85	100	5.6	66	1.2	1200	0.44	46	1.5	.12	3.0	340	0.12	4800	130	7.3
Mean	0.6	18	0.4	0.5	31	21	35	14	1.6	39	0.2	260	0.18	13	0.7	.08	0.9	130	0.08	2900	49	4.4
Minimum	0.3	0.9	<0.1	0.2	5	7	14	3	0.4	10	0.1	40	<0.03	4	0.3	.05	0.1	20	0.02	1400	16	3.5
Std. dev.	0.3	29	0.3	0.3	22	23	18	26	1.4	17	0.3	310	0.1	10	0.4	.02	0.8	93	0.03	1100	29	0.9
Soil(2-5 cm)																						
Maximum	1.5	37	1.3	0.8	74	90	59	110	2.6	60	1.0	450	0.33	36	1.6	.06	2.0	460	0.14	5800	110	7.7
Mean	0.8	6.3	0.6	0.3	20	24	26	14	1.1	29	0.18	110	0.11	9	0.6	.03	0.7	130	0.05	3800	35	4.4
Minimum	0.3	0.6	<0.1	.09	<5	8	8	4	0.3	9	0.05	27	<0.03	3	0.1		0.2	23	<0.01	1400	7	3.9
Std. dev.	0.4	9.6	0.3	0.2	26	20	14	26	0.7	15	0.23	120	0.09	8	0.4	.01	0.5	110	0.04	1300	25	0.9
Contaminant guidelines[a]		10.0	3.0			50	60		3.5	150	1.0	700	0.15	60			2.0		0.10		500	

[a] Applies only to 0-5 cm soil.
[b] Extractable chloride.

TABLE 6. Average levels of arsenic ($\mu g/g$, dry weight) and iron (percent, dry weight) in three depths of soil, Atikokan, 1981-84 and 1986.

	Soil (0-1 cm)				Soil (1-2 cm)				Soil (2-5 cm)			
	As		Fe		As		Fe		As		Fe	
Site	1981-84	1986	1981-84	1986	1981-84	1986	1981-84	1986	1981-84	1986	1981-84	1986
1	51	120	2.9	6.9	15	48	1.5	2.6	5	5	1.5	1.0
2	29	75	1.9	3.2	8	15	1.3	1.2	8	4	1.3	0.7
3	21	32	1.5	1.7	14	8	1.4	1.5	9	6	1.9	2.0
4	84	160	4.3	9.9	30	110	1.6	5.6	11	37	0.8	2.6
5	5	6	0.6	0.7	5	5	0.5	0.8	3	3	0.5	0.8
6	3	3	0.5	0.4	3	2	0.6	0.4	3	<1	0.5	0.3
7	13	7	1.0	1.1	4	2	0.9	0.5	2	<1	1.3	0.8
8	70	32	3.9	2.7	18	12	1.4	1.5	10	1	1.4	1.1
9	14	15	1.0	1.2	10	11	1.3	1.3	7	5	1.3	1.1
10	2	1	0.5	0.4	2	<1	0.5	0.4	2	<1	0.4	0.4
11	86	44	4.4	3.5	43	45	2.6	2.9	43	18	1.5	1.2
12	46	8	4.0	2.7	28	3	3.9	3.0	20	1	4.1	2.4
13	6	4	0.6	7.2	4	2	0.6	0.6	2	<1	0.6	0.4
14	17	16	1.6	9.7	9	7	1.8	0.9	4	4	2.7	0.6
15[b]	15	15	1.2	1.1	8	6	0.9	0.8	6	6	0.3	0.8
Mean	31	36	2.0	2.5	14	18	1.4	1.6	8	6	1.4	1.1
Contaminant[a] guideline	10		3.5		10		3.5		10		3.5	

[a]Applies only to soil 0-5 cm in depth.
[b]Sampling began in 1983.

TABLE 7. Precipitation chemistry[a] at three sites in northwestern Ontario, 1982-84 and 1986.

Parameter	Quetico Centre 1982-84	Quetico Centre 1986	Fernberg Road 1982-84	Fernberg Road 1986	Forbes Township 1982-86	Forbes Township 1986
	pH[b] and concentrations (mg/l)[c]					
pH	5.1	5.2	5.2	5.1	5.0	5.2
SO_4	1.0	1.1	1.0	0.8	1.2	1.2
NO_3	0.2	0.2	0.2	0.2	0.2	0.2
NH_4	0.2	0.2	0.3	0.2	0.2	0.2
	Wet deposition rates (kg/ha/year)					
SO_4	4.8	5.5	5.7	N/A[d]	5.4	5.2
NO_3 (as N)	0.9	1.1	1.2	N/A	0.9	1.0

[a] Based on event data.

[b] Arithmetic mean.

[c] Volume-weighted means

[d] Not available.

TABLE 8. Concentrations of selected parameters in meltwater from snow collected in February, 1986. All elemental values are in $\mu g/l$, except for carbon and residues (in mg/l) and conductivity (in μmhos/cm).

Parameter	Maximum	Mean	Minimum	Standard deviation	Guideline
Aluminum	87	47	10	23	500
Arsenic	1	<1	<1	0.15	30
Cadmium	2	<0.5	<0.5	0.5	3
Calcium	790	390	180	230	2000
Chloride	130	33	<10	42	4000
Chromium	3	<2	<2	0.6	
Copper	2	<1	<1	0.5	60
Fluoride	<100	<100	<100	0	
Iron	160	47	17	40	700
Lead	4	<3	<3	1	50
Magnesium	200	<70	<70	51	400
Manganese	3	2	1	1	20
Mercury	<0.03	<0.03	<0.03	0	0.1
Nickel	6	2	<2	2	40
Phosphorus	10	5	2	3	20
Potassium	90	45	<40	30	1000
Selenium	<30	<30	<30	0	
Sodium	<200	<200	<200	0	2000
Sulphate	1300	740	530	250	3000
Titanium	<10	<10	<10	0	10
Vanadium	<10	<10	<10	0	
Zinc	6	2	<1	2	300
Residue filtrate	11	2	<0.2	3	30
Residue particulate	3	0.8	<0.1	1	25
Residue total	14	3	<0.2	4	40
Dissolved inorganic carbon	<0.4	0	0	0.1	1
Dissolved organic carbon	2.7	1.0	<0.4	0.7	2
Total particulate carbon	2.5	1.2	0.7	0.5	7
Conductivity	12	9	6	2	45
pH	6.1	5.3	4.8	0.5	